Digitized by the Internet Archive
in 2012 with funding from
CARLI: Consortium of Academic and Research Libraries in Illinois

http://archive.org/details/easternwoodratre00nawr

A FINAL REPORT

EASTERN WOODRAT RECOVERY - PHASE I: HABITAT PROTECTION AND POPULATION ENHANCEMENT

Presented to:

Sue Lauzon
Endangered Species Program Coordinator
Illinois Department of Conservation
524 S. Second Street
Lincoln Tower Plaza
Springfield, Illinois 62706

August 28, 1986

Prepared by:

Jack R. Nawrot

James Spitzkeit

James Spitzkeit

Approved by:

Alan Woolf, Assistant Director
Cooperative Wildlife Research Laboratory
Southern Illinois University--Carbondale

EASTERN WOODRAT RECOVERY - PHASE I: HABITAT PROTECTION AND POPULATION ENHANCEMENT

INTRODUCTION

The eastern woodrat, Neotoma floridana, is currently listed as an endangered species in Illinois (Illinois Department of Conservation Administrative Order 138: Illinois List of Endangered and Threatened Vertebrate Species). Field studies and surveys during the last three decades document a substantial reduction in the distribution and numbers of the only race (N. f. illinoensis) represented in Illinois (Crim 1961, Nawrot 1974, Nawrot and Klimstra 1976, 1981, Anderson and Klimstra 1982, Sweet 1983, West 1986). This has been attributed to climatic extremes, scientific collection, and other human disturbance (Nawrot 1974).

Current distribution is now limited to Pine Hills in Union County with active nests in Sections 9, 16, 21, and 28 of Township 11S, Range 3W and a population of 15-30 individuals (West 1986). Preservation of this remnant population will depend on annual monitoring, affording maximum protection to existing habitat and implementation of management practices. Furthermore, natural recovery from such a low level may be questionable; consequently, methods to enhance the present population must be considered.

To promote recovery of N. f. illinoensis in Illinois both habitat protection and population enhancement measures should be developed and implemented as soon as possible. To provide historic background and initial guidance for implementation of a recovery plan, this report presents background information on taxonomy, distribution, life history, habitat needs, and population status of N. f. illinoensis. The following is provided for implementation of specific recovery plan measures:

1) establish site specific habitat protection/management plans based on current population distribution,

2) develop standardizing methods to be used in annual population monitoring, and

3) make a decision on population enhancement through reintroduction of captive bred and/or translocated individuals.

BIOGRAPHIC SUMMARY

Subspecies Description

Neotoma floridana illinoensis was first described by Howell (1910). Like other eastern woodrats, its appearance is characterized by large, rounded, and sparsely haired ears; large black eyes; soft pelage; and tail covered with short hairs (Rainey 1956). Backs and sides of adults are grayish-brown to cinnamon tinged with black in varying intensities; the face is noticeably grayer, especially in older animals (Howell 1910, Layne 1955, Rainey 1956). Subadults are gray over the entire upper surface (Layne 1955). Howell (1910) reported average measurements of eight adults collected from Wolf Lake, Illinois: total length, 430 mm (390-435); tail, 195 mm (187-205); hind foot, 38 mm (36-40). Average weight of adult males measured by Nawrot (1974) was 295 g (255-370); adult females averaged 278 g (260-320).

Taxonomy

Nawrot (1974:1) presents the following information:

> Woodrats were first noted in North America by Peter Kalm in 1749 in the Blue Mountains of Pennsylvania (Murphy 1952). In 1818, Ord assigned a woodrat taken in Florida to the Old World Family of rats and mice and designated it *Mus floridanus*. Thomas Say rediscovered the woodrat along the Mississippi River below St. Louis in 1819, and later in 1825 with Ord, designated the new genus *Neotoma* (Burroughs 1961).

Opinions regarding the subspecific taxonomy of *Neotoma floridana* have varied over the years (Schwartz and Odum 1957, Hall and Kelson 1959, Birney 1973). Hall (1981) recognized 10 subspecies of the eastern woodrat in the southeastern United States (Fig. 1). Howell (1910) first described *N. f.*

illinoensis from specimens collected at Wolf Lake, Union County, Illinois; the type specimen was collected at that location by John Johnson on 12 January 1910.

Distribution

N. f. illinoensis is presently found in 10 of the southeastern states (Hall 1981). Located on the periphery of the subspecies' range, the population in southern Illinois is geographically isolated from woodrat populations in adjacent states. Specimens of *N. f. illinoensis* have been reported 120.7 km (75 mi) to the west in Missouri, and 136.8 km (85 mi) to the south in Tennessee. The Allegheny race (*N. f. magister*) has been recorded 225.3 km (140 mi) to the southeast in Kentucky, and 281.6 km (175 mi) to the east in Indiana (Schwartz and Odum 1957). The former range of the woodrat in Illinois included much of the Shawnee Hills region in southern Illinois and the Mississippi River bluffs, perhaps as far north as the East St. Louis area (Nawrot and Klimstra 1976, Parmalee 1967) (Fig. 2). Nawrot and Klimstra (1976) located 24 areas of past woodrat populations in the Shawnee Hills, including sites in Jackson, Union, Johnson, Pope, Gallatin, and Hardin counties (Table 1). Parmalee (1959) and Parmalee et al (1961) reported evidence of former woodrat populations in Randolph and Monroe counties and Wetzel (1947) documented their occurrence near Olive Branch in Alexander County. The population in Illinois is now limited to Pine Hills in Union County (Fig. 3).

Life History

Nest Sites. Woodrats are nocturnal, solitary rodents which remain active year round. In Illinois, they inhabit steep bluffs bordering the bottomlands of the Mississippi River. These rough, broken cliffs provide protective crevices and ledges used for nest sites and travel routes to and from surrounding foraging areas (Layne 1955).

Nests of bark, sticks, and leaves are constructed in crevices and cave-like depressions in the cliffs, although overhanging ledges and the base of the bluffs and rock outcrops are also used (Nawrot 1974). The nests, which provide some protection from predators and inclement weather, vary in shape and size depending on dimensions of the surrounding shelter type and degree of woodrat maintenance activity. Nawrot (1974) observed nests ranging from a few scattered sticks at the opening of a crevice to piles of debris measuring 5 feet long and 3 feet high in small cave-like depressions. In addition to vegetative materials typical "pack rat" items such as pieces of broken glass, bottle caps, rusty nails, shotgun shells, old bones, and turtle shells are often found at nest sites (Nawrot 1974).

Food Habits. The eastern woodrat is generally considered a herbivore, foraging at night on a variety of plant and limited animal material in the vicinity of house sites; frequently large quantities of food items are stored during fall months (Rainey 1956). The woodrat is adaptable in its feeding habits and the type of available food is not a limiting factor. Nawrot (1974:51) reported the following regarding food habits of the woodrat in Illinois:

> Sixty food items were reported by Crim (1969) as being utilized throughout the year. Almost all items were deciduous tree leaves and mast, with chinquapin, red, black, and white oak leaves and acorns, maple leaves, and red bud leaves and seed ponds accounting for more than 50 percent of all food items observed. Seasonal variation in food items was also reported; April through May annuals were eaten in large quantities; June through July deciduous tree leaves were the main food items; August through October oak acorns and other species were collected and stored; and from November through March little food was gathered except for cuttings of ferns and red cedar.

Reproduction. According to Hamilton (1953), the eastern woodrat may breed throughout the year in the southeastern United States. In Illinois, sexual activity begins in late January and increases through February to peak activity March to May (Nawrot 1974). Adult males examined by Nawrot (1974) in October, November, and December were sexually inactive.

Females are capable of breeding during their first year (Nawrot 1974, Rainey 1956). The majority of litters are born during May and early June after a gestation period of approximately 33 to 41 days (Nawrot 1974, Pearson 1952, Rainey 1956). Nawrot (1974) found evidence of second or late litters in Illinois, but normal reproductive potential is one litter per female per year. Litter size is usually from 2 to 4 (Layne 1955); examination of reproductive tracts of 14 female Illinois woodrats (Unpublished data, Cooperative Wildlife Research Laboratory, reported by Nawrot 1974) revealed an average of 2.6 embryos per female. Seemingly, the reproductive potential of the woodrat is low compared to many species of rodents; however, Rainey (1956) believes this inherently low reproductive rate may be compensated by the house structures which provide protection from predators.

Young are born blind, nearly naked, and helpless (Layne 1955). The incisors of the young are adapted for attachment to the nipples of the mother (Hamilton 1953), and nursing young often remain fixed to the female when she is forced to leave the nest. The young are well furred by the time their eyes open at 15 days (Layne 1955). The young are weaned at about 4 weeks (Hamilton 1953), and by about 10 weeks are fully independent (Layne 1955).

Home Range/Movement. The home range of a woodrat is defined by movements directed outwards from the home site along the base of the bluff and into the surrounding woods. Travel across open spaces is avoided; they follow protected trails through crevices and under ledges whenever possible (Nawrot 1974). Most activity occurs between dusk and midnight (Wiley 1971).

Nawrot (1974) described movements of Pine Hills woodrats based on recaptures of marked individuals. Distances between recaptures averaged 85 feet (0 to 285); however; Nawrot (1974) noted that this probably underestimates the distance of natural movements since the woodrats were trapped as they moved

along the outcrop in search of food. Fitch and Rainey (1956) suggested that woodrats wander frequently from one house to another in areas with unoccupied house sites. Nawrot (1974) observed frequent movement among unoccupied nest sites in the Pine Hills area; however, most woodrats only moved back and forth between adjacent sites during recaptures. Woodrats (n=46) that were captured more than one time were taken at an average of 1.9 different sites (Nawrot 1974).

Woodrats are territorial, and intraspecific intolerance results in a minimal distance between active houses (Wiley 1971, Fitch and Rainey 1956). Consequently, spacing between adjacent active house sites must be short enough to allow social interaction; but, far enough to provide adequate living space and prevent constant territorial strife. In Pine Hills, the optimum distance between adjacent sites appeared to be less than 100 feet (Nawrot 1974).

Predation. Crim (1961) listed 21 species of animals considered potential predators of the woodrat in Pine Hills. The most effective predators are those able to pursue the woodrat within its protective nest, such as snakes. Crim (1961) considered the racer (*Coluber constrictor*), black rat snake (*Elaphe obsoleta*), cottonmouth (*Agkistrodon piscivorous*), timber rattlesnake (*Crotalis horridus*), and copperhead (*Agkistrodon contortrix*) the greatest threat, especially to the young. Nawrot (1974) observed all of these snakes but the copperhead in the vicinity of active woodrat houses. Fitch and Rainey (1956) considered the woodrat one of the most important prey species of timber rattlesnake since both are nocturnal in activity. However, Perez et al (1978) reported evidence of natural resistance to rattlesnake (*Crotalus atrox*) venom in the woodrat *Neotoma micropus*.

Habitat Description

In the northwest part of its range, the eastern woodrat is found in rocky situations such as caves, outcrops, dry rocky hillsides, and intermittent woody stream courses with sparse vegetation (Rainey 1956). Nawrot (1974:8-10) provides the following description of Pine Hills:

> The Pine Hills area, located in the southern section of the Ozark Division (Schwegman 1973), is characterized by its north-south oriented expanse of Devonian age Bailey limestone bluffs which rise abruptly above the Mississippi River bottoms (Weller and Ekblaw 1940). The sheer bluffs reach as high as 160 feet in some places, and average 80 feet in either smooth vertical faces or rough broken walls (Baskett 1925, Weller and Ekblaw 1940). Swampland borders the bluffs among much of the southern 5 miles, with LaRue Swamp bordering the northern bluffs, and Otter Pond, and Wolf Lake, remnants of an old channel of the Big Muddy River, bordering the southern end (Mohlenbrock 1959).
>
> The geographic diversity of this area has resulted in the recognition of several distinct habitat types (Ashby and Kelting 1963); of which, the lowland midslope, and upland forest communities are considered of importance to the woodrat population. Beech (*Fagus grandifolia*) and tulip poplar (*Liriodendron tulipifera*) are often the dominant lowland canopy species in association with sweetgum (*Liquidambar styraciflua*), chinquapin oak (*Quercus muhlenbergii*), sugar maple (*Acer saccharum*), shagbark hickory (*Carya ovata*), and ashes (*Fraxinus* spp.) (Ashby and Kelting 1963; Voigt and Mohlenbrock 1964).
>
> Typical understory trees and shrubs of the lowland forest include pawpaw (*Asimina triloba*), spice bush (*Lindera benzoin*), redbud (*Cercis canadensis*), bladdernut (*Staphylea trifolia*), service berry (*Amelanchier arborea*), and flowering dogwood (*Cornus florida*). Poison ivy (*Rhus radicans*), and grape (*Vitis* spp.) are common species of both the lower and midslope communities.
>
> Dominant tree species of the midslope are bitternut hickory (*Carya cordiformis*), black oak (*Quercus velutina*), red oak (*Q. rubra*), and some white oak (*Q. alba*), while the upland forest community also contains white oak and post oak (*Q. stellata*) as dominant canopy species (Voigt and Mohlenbrock 1964). Additional tree species of the more xeric south- and west-facing upper slopes and ridges are red cedar (*Juniperus virginiana*), blackjack oak (*Quercus marilandica*), and yellow pine (*Pinus enchinata*), which is sparsely distributed along the upper chert outcrop (Ashby and Kelting 1963).
>
> Understory vegetation of midslope and ridge communities includes many species of the lower slope in addition to hop hornbeam (*Ostrya virginiana*), New Jersey tea (*Ceanothus americana*), goat's rue (*Tephrosia virginiana*), and a characteristic shrub layer of farkleberry (*Vaccinium arboreum*), and wild azalea (*Rhododendron roseum*) on the cherty upper slopes (Ashby and Kelting 1963).
>
> Hill prairies are an important habitat type of a small number of woodrat sites located on the grassy upper slopes. Important

vegetation of these upland grass communities is little bluestem (Andropogon scoparius), side oats gramma (Bouteloua curtipendula), big bluestem (Andropogon gerardi), and Indian grass (Sorghastrum nutans).

Although not as abundant as oaks and hickories, honey locust (Gleditsia triacanthos), and the Kentucky coffee tree (Gymnocladus dioca) also serve as important food sources when available near active woodrat sites.

Associated Species

In addition to the woodrat, the LaRue-Pine Hills Ecological Area provides habitat for several rare, endangered, or unique species. Among these are the spring cavefish (Chologaster agassizi), least shrew (Cryptotis parva harlani), Indiana bat (Myotis sodalis), swamp rabbit (Sylvilagus aquaticus aquaticus), bog lemming (Synaptomys cooperi gossii), rice rat (Oryzomys palustris palustris), bobcat (Lynx rufus), spine softshell (Trionyx spinifer), northern red-bellied snake (Storeria occipitomaculata occipitomaculata) and the eastern hognose snake (Heterodon platyrhinos) (U.S. Forest Service 1970).

Reasons for Low Population and Decline

Nawrot and Klimstra (1976) suggest climatic extremes precipitated the elimination of the woodrat from the Shawnee Hills and the decline of woodrat populations in Pine Hills. Southern Illinois experienced abnormally severe winter weather in 1912 and 1918, with prolonged below zero (°C) temperatures and snow cover (Fig. 4). The severe weather in 1912 might have precipitated the initial population decline, which was continued and possibly aggravated by the even harsher winter of 1918. Woodrat populations scattered through isolated areas of marginal habitat in the Shawnee Hills were possibly reduced to such low levels that other mortality factors had a greater influence in hindering recovery (Nawrot and Klimstra 1976). For example, predation would have a much greater impact, since at low population levels, woodrats tend to wander greater distances between vacated house, increasing their vulnerability (Rainey

1956). By 1950, woodrats no longer inhabited the Shawnee Hills (Nawrot 1974). Woodrats survived in the Pine Hills area probably because this area provided more continuous, higher quality habitat, enabling initial woodrat populations of higher densities. However, the severe winters of 1912 and 1918, and later in 1960, and late 1970's may have reduced the Pine Hills population to the unstable levels evidenced today (Fig. 4).

Collection of specimens for scientific purposes may have also contributed to the woodrat population declines. Between 1959 and 1974, at least 145 specimens were collected by museums and universities from Horseshoe Bluff, Fountain Bluff, and Pine Hills (Nawrot 1974). Other forms of human disturbance may also have exacerbated population declines. Woodrat house sites located along the base of the bluffs and rock outcrops in Pine Hills area may have been adversely affected by activities such as widening of the access road and pruning of tree limbs which obscure the scenic view of the bluffs (Nawrot 1974). Where the bluff closely parallels the access road (Pine Hills Section 16), Nawrot (1974) found only 2 active woodrat sites compare to 14 active sites found in 1960 (Crim 1961).

Current Population Status

Woodrat population levels in the late 1950's and early 60's exceeded 150 individuals in the Pine Hills area. However, by the early 1970's, Nawrot (1974) estimated the Pine Hills population to be between 50 and 75 woodrats. By the mid 1970's it was suggested that the southern Illinois woodrat population was in a slow decline. Subsequent monitoring (1980-1983) of nest sites by personnel of the Illinois Department of Conservation and the Cooperative Wildlife Research Laboratory (CWRL) indicated a further decline may have occurred as suggested by a recent population estimate of only 15 to 30 individuals (West 1986). Although the 1985 (West 1986) estimate is the lowest to date, a

preliminary assessment of nest sites conducted by CWRL personnel in May 1986 suggested population levels (as based on signs of active nest sites at Otter Pond) were equal to if not greater than those estimated in the mid-1970's.

Although population levels in the Pine Hills may be no lower than 10 years ago (i.e., 50-75 woodrats), it is questionable that natural recovery will occur without efforts to enhance genetic diversity and reproductive potential. To expedite recovery and/or implement a plan of action to ensure protection of the current population, the following elements of Phase I of the Eastern Woodrat Recovery Plan will be discussed: 1) habitat protection and 2) population enhancement.

HABITAT PROTECTION

Former range of the woodrat in Illinois included much of the Shawnee Hills region in southern Illinois and the Mississippi River bluffs, as far north as the East St. Louis area (Parmalee 1967, Nawrot and Klimstra 1976). Woodrats have survived in the Pine Hills area because it has provided more continuous, higher quality habitat contributing to initial populations of greater density than elsewhere in the Shawnee Hills. As repopulation of the former woodrat range in other areas of the Shawnee Hills may now be impossible due to the presence of man made barriers and destruction of natural dispersal routes (Nawrot and Klimstra 1976), a realistic objective in the recovery of the woodrat is to maintain and protect the Pine Hills habitat as top priority. Protection is crucial to eventual recovery, as this area has the capacity to support as many as 400 to 500 woodrats.

Until 1970 management of Pine Hills focused primarily on recreation. In 1970, 1,996 acres of river bottom and limestone bluffs were designated the LaRue-Pine Hills Ecological Area which has since been managed for recreational

use pursuant to protection and preservation of the area's unique botanical and zoological values (U. S. Forest Service 1970).

Major habitat changes evident from a review of aerial photographs taken over the last 4 decades indicate an increase in the amount of open water in the swampland bordering the bluffs and an increase in forest canopy cover on the bluffs. Beaver (*Castor canadensis*) stocked in the LaRue Swamp in 1938 (U.S. Forest Service 1970) are directly responsible for the increase in open water, flooding of privately owned cropland adjoining Pine Hills, and periodic flooding of the lower bluff road (LaRue Environmental Assessment Maintenance Project 1986). Increase in tree canopy indicates maturation of the hills into an oak-hickory climax community, with a decrease of some of the hill prairies found on the bluffs. Nawrot (1974) suggested hill prairies represented an important habitat type for a small number of woodrat nests located on the grassy upper slopes. Although it may be suggested that the increase in overstory and subsequent decrease in understory may be subjecting woodrats to increased predator exposure during foraging it can be assumed that this factor is not critical as mature forest conditions were a dominant habitat feature when woodrats occupied the entire expanse of the Shawnee Hills prior to 800 A.D. Consequently, habitat management suggestions such as controlled burning to enhance food and cover diversity may be inappropriate in view of the woodrat's past record of population abundance and distribution in "presumed" prehistoric native forest conditions.

Picnic areas, scenic overlooks, a parking lot at Winters Pond, and the upper and lower bluff roads represent the major development of the area (U.S. Forest Service 1970). The proximity of the lower road to the bluffs represents the greatest potential for human impact. Cudmore (1983) found that 61% of foraging by woodrats occurred at cliff bases in southern Indiana. Beaver

induced flooding of the road may have affected foraging of woodrats nesting in these areas through inhibiting access to, and reduction of the adjacent bottomland forest habitat. Evidence of deliberate burning of woodrat nests along the road has also been noted as a possible consequence of increased visitor access (Jack Nawrot, pers. comm.).

In light of the extremely sensitive and vulnerable status of the woodrat at Pine Hills, road development or expansion, vegetation removal or disturbance, and greater public access have potential serious impact on the current population. To ensure minimum disturbance, restricted access to all areas of present woodrat concentration and potential future release sites may be necessary. Sweet (1983) suggested road closure during the breeding season (March-September). Obtaining additional protection may be difficult in view of multi-use Forest Service policy, yet is probably the most critical factor in preserving this native resource.

Although not as critical to immediate recovery goals, long-term protection and maintenance of desirable habitats at Fountain Bluff and Horseshoe Bluff in Jackson County should be considered. The abundance and quality of nest sites associated with these sandstone bluffs were considered "marginal" in light of the quality habitat at Pine Hills (Nawrot 1974). However, the relatively recent occupation of the Fountain Bluff and Horseshoe Bluff sites demonstrates the value of the availability of adjacent habitat to ensure dispersal and survival of expanding populations. Although protection of these areas is not top priority, habitat integrity must be protected if any reintroduction at Fountain Bluff and Horseshoe Bluff proves a prudent recovery tactic should sufficient woodrats become available.

Monitoring

The interest in Illinois wildlife resource and woodrat population monitoring of recent years have identified trends for the Illinois woodrat interpreted as "too low for natural recovery". Although population fluctuations such as these may have occurred unrecorded in pre-historic times, current interest in success of recovery measures will necessitate a systematic monitoring effort.

A standardized annual survey of the existing woodrat population at Pine Hills is fundamental to determining current status, population trends, and evaluation of any reintroduction efforts. Since current population levels are probably too low to permit live-trapping, accurate estimates of woodrat numbers may be extrapolated from numbers of active nests observed, using a nest to woodrat ratio of 1.36:1. Debris piles, scats, fresh cuttings, tracks, and food caches are reliable indicators of current utilization (Nawrot 1974).

Monitoring should be conducted in early spring at the first emergence of green vegetation and/or late fall prior to disappearance of all green vegetation. Several advantages of a spring survey include sparse vegetative cover making location of nest sites, reference points, outcrops, etc. more efficient. As green cuttings would be at a premium in the spring, their presence at nest sites would be a reliable indicator of activity. Spring population estimates would reflect not only surviving adults, but would include juveniles that have successfully overwintered. Problems associated with late fall monitoring include lack of green vegetation with the exception of evergreens such as red cedar. As red cedar cuttings remain green longer than other vegetation, this species is not a reliable indicator of recent activity. In addition, dormant vegetation may still obscure nest sites and reference points.

Surveys should include all sites identified during previous surveys and studies (Crim 1961, Nawrot 1974, Anderson and Klimstra 1982, Sweet 1982-85, West 1986) in Sections 9, 16, 21, and 28. Occasional spot checks should be made in Section 33, adjacent to the Wolf Lake Powder Plant as well as other portions of favorable bluff habitat in the vicinity of Olive Branch. Surveys should begin in Section 28 at Otter Pond and continue northward through Section 9. New sites encountered should be designated by the year and a number indicating the order in which they were encountered (e.g., 1986-1, 1986-2, etc.). Complete photo documentation should be made of new sites and should include landmarks, compass bearings, and accurate field notes to aid in future monitoring. New nest sites should be marked with durable metal tags, semi-permanently attached to prevent their incorporation into the nests themselves. Tags should be placed approximately 1m directly above the center of the nest site when possible.

POPULATION ENHANCEMENT

Recent estimates of the Pine Hills woodrat population suggests natural recovery is questionable, especially in the near future. To enhance and restore the remnant woodrat population, introduction of _N_. _f_. _illinoensis_ from outside sources is probably the only option. A viable, self-sustaining population may require 500 or more reproductive members to maintain sufficient genetic diversity for a stable and healthy population (Soule 1980, from Ahlsted 1983); however, this figure may vary in relation to life expectancy, productivity, and other factors. Introduction of woodrats from outside sources would immediately increase genetic diversity and give balance the reproductive potential of the Pine Hills population.

Introduction of new individuals can be achieved in two ways: 1) direct translocation of individuals from self-sustaining populations of *illinoensis* in neighboring states, and/or 2) release of individuals bred in captivity.

Translocation

Population enhancement through translocation of "surplus" individuals from adjacent states superficially appears a straightforward approach to achieving rapid recovery of the woodrat population. Unfortunately, such attempts have met questionable success as a result of poor survival attributable to release method, habitat suitability, and acclimatization.

Reintroduction efforts have not been attempted for *N. f. illinoensis*; how-however, there is documentation for other subspecies. In 1970, Key Largo woodrats (*N. f. smallii*) were successfully established in a previously unoccupied area of Lignum Vitae Key, Florida. From an initial 19 rats, the population has increased to an estimated 85 individuals (Brown and Williams 1971, Barbour and Humphrey 1982).

In 1983, an attempt was made to reintroduce the Allegheny woodrat (*N. f. magister*) to Neotoma Valley, Hocking County, Ohio. A total of 44 rats were released over a 2-year period; only 2 could be accounted for by the end of the study. All 18 woodrats released in 1983, and 24 of 26 released in 1984 died or were never found. Poor survival was attributed to predation resulting from excessive post-release movement. Low population levels, a lack of suitable crevices for nesting and cover, and release induced stress were identified as likely causes of the excessive movement (Schlie 1985).

Breeding Stock Acquisition

The present range of *N. f. illinoensis* includes Tennessee, Mississippi, Alabama, Arkansas, Missouri, and Louisiana (Hall 1981). To determine the avail-

ability of *N. f. illinoensis* for restocking or captive breeding stock, endangered species coordinators and biologists were contacted in each of these states (Appendix A). With exception of Tennessee where the woodrat is endangered, all states responded favorably to the possibility of providing rats. However, most individuals contacted were not aware of subspecies distribution or specific populations that could be trapped within their states. In view of this general lack of specific knowledge regarding the health and stability of potential donor populations from adjacent states, location of a suitable source will require close communication with these states' representatives. Final source selection should be based on identification of those populations existing in similar habitat capable of sustaining removal of individuals without detriment.

Woodrats may be trapped and transported using Tomahawk live traps (15x15x 60 cm) baited with a mixture of oats and peanut butter and/or apples (Schlie 1985). Traps should be placed at active nest sites and checked daily. The following data should be collected for all trapped rats:

1) weight
2) sex
3) reproductive status
4) total length
5) tail length
6) right hind foot length

Prior to release, #3 monel metal ear tags should be affixed to each ear.

Release Methods

The method of release can have both a short and long term effect on survival of reintroduced woodrats. It is suggested that a "gentle" method of release after Schlie (1985) be utilized to maximize acclimatization of translocated individuals; survival was significantly longer as compared to direct releases. In a gentle release, rats are retained for at least 7 days in 38x

76x33 cm (1.25 cm mesh) holding cages at release sites. Ample supplies of food and water as well as mulch-filled, 33x23x23 cm nest boxes are provided. After approximately 7 days, holes are cut in the holding pens and woodrats are free to move out at will. Supplemental food may be provided in addition to leaving the cage at the release site for use by the woodrat. To enhance "acceptance" of the release area by introduced woodrats, rehabilitation and/or construction of nest sites could be beneficial. Gathering and placement of sticks, twigs, and leaves in abandoned nest areas, and provision of natural food supplies (acorns, seed pods, fresh twigs and buds, etc.) may minimize detrimental wandering by recently released woodrats.

Release Sites

Two potential release areas were identified during field surveys on 9 and 13 May 1986. The first area is located among the limestone bluffs adjacent to Otter Pond in Section 28 (T11S R3W Union Co.); the woodrat group inhabiting this area was designated Colony VI by Nawrot (1974). In the fall of 1972 this area contained 15 active woodrat houses used by 9 rats and 11 woodrats were present in 1973 (Nawrot 1974). Nawrot (1974) considered this colony to be the most potentially successful compared to other colonies inhabiting Pine Hills based on number of rats, low turnover rate, number of active sites and favorable habitat. More recently, West (1986) noted only 2 active nests in 1985, but in 1986 as many as 2/3 of all nest sites encountered at Otter Pond appeared to be in use.

The second area is represented by the expanse of bluffs extending the length of Section 16 (T11S R3W Union Co.). Nawrot (1974) identified 3 colonies for a total of 27 active nests in this area in the early 1970's and West (1986) found 15 in late fall of 1985, representing probably the greatest density now at Pine Hills.

Otter Pond area of Section 28, and the central segment of Section 16 reflect the best available habitat at Pine Hills as evidenced by past and present occupation. Availability of protected nest sites and release of approximately 50 rats each in Section 16 and 28 at Otter Pond represents a realistic goal for initial restocking efforts. Supplemental restocking should be included in reintroduction plans for subsequent years. Rats should be released in the spring after leafout, providing optimum conditions for acclimatization and survival in terms of food, cover, and climate. If sufficient woodrats are available for release, consideration should also be given to concurrent restocking of the Fountain Bluff and Horseshoe Bluff sites. Dependent upon success of initial stocking efforts, consideration should be given to eventual restocking of past areas of occupation in the Shawnee Hills such as Burden Falls, Bell Smith Springs, Garden of the Gods, Ferne Clyffe, Lusk Creek, Jackson Hollow, etc. Introduction to other sites characterized by suitable habitat could include areas such as inactive rock quarries and surface mine highwalls of southern Illinois. Such extensive stocking efforts would minimize the potential impacts of single or localized adverse effects such as disease or major habitat disturbance.

Captive Breeding

Captive breeding has been used successfully to supplement natural production for restoration of populations of endangered species. Fundamental to the success of such efforts has been:

1) testing methods for obtaining and transporting stock
2) developing suitable artificial incubation and rearing procedures
3) developing suitable pen facilities and pairing procedures
4) testing medical and sanitation procedures, and
5) preparing captive-reared animals for an independent existence in the wild (Erickson 1980)

The eastern woodrat has been raised and bred successfully in captivity for behavioral and life history studies (Poole 1940, Worth 1950, Kinsey 1976, 1977); but no studies emphasized production of individuals for release into the wild. Poole (1940) raised 4 pairs of Allegheny woodrats under essentially "laboratory" conditions producing 4 litters. Worth (1950) raised a small number of Florida woodrats successfully under similar conditions and Kinsey (1977) after 22 months obtained a population of 24 Allegheny woodrats from a single breeding pair. These rats were held under conditions designed to simulate the natural environment.

These studies indicate captive breeding of woodrats is feasible; however, production is secondary to "preparing captive-reared animals for an independent existence in the wild." To ensure suitable survival of captive bred stock, woodrats should be raised in a simulated natural environment similar to that used by Kinsey (1977). In this study a 65 square m enclosure of hardware cloth and lumber containing shelves, ramps, straw, and pipes was used to simulate the natural environment of the Allegheny woodrat. The enclosure was located in a barn loft, exposed to ambient light and temperature, and food provided *ad libitum*.

Establishment of an outdoor breeding colony would have even greater potential for production of "acclimated" woodrats. Constructed with natural materials, such as rocks and logs, and provided with natural nest and food materials would be beneficial in conditioning offspring for a gentle release from similar conditions at release sites. Woodrats maintained under such conditions would undoubtedly have a better chance of surviving in the wild than those raised under more artificial laboratory conditions; but survival may be poorer than for translocated individuals.

Although development of a captive breeding program for the Illinois woodrat should be considered, its merits require careful evaluation. When compared to other rodents, woodrats are not as prolific, producing annually 2-3 litters of 2-4 young each (Lowery 1974). With maximum survival production of significant numbers in captivity may not be cost-effective. Experience of the Patuxent Wildlife Research Center, Laurel, Maryland, at the forefront of captive propagation of endangered species, has shown the difficulties and time involved in being successful (Erickson 1980).

SUMMARY

Restoration to a non-threatened or non-endangered status is a long-term goal of the woodrat recovery plan. Habitat and animal protection is fundamental to preserving woodrat populations in Illinois and preventing acceleration of decline. Habitat protection and elimination of past human disturbance now allows the implementation of a successful stocking program, which could ultimately lead to reestablishment of this unique species throughout its former range in southern Illinois.

LITERATURE CITED

Ahlsted, S. 1983. Technical/agency draft recovery plan for the rough pigtoe pearly mussel Pleurobema plenum (Lea 1940). Prepared for U.S. Fish and Wildlife Service Endangered Species Field Office, Asheville, NC. U.S.F. W.S. Contract No. TV-60706A. 47pp.

Anderson, E. and W. D. Klimstra. 1982. Current status of the endangered Illinois woodrat. Job Completion Report to Illinois Dept. of Conserv., Springfield, IL. 8pp.

Ashby, W. C. and R. W. Kelting. 1963. Vegetation of the Pine Hills Field Station in southwestern Illinois. Trans. Illinois State Acad. Sci. 56(4):188-201.

Barbour, D. B. and S. R. Humphrey. 1982. Status and habitat of the Key Largo woodrat and cottonmouse (Neotoma floridana smalli and Peromyscus gossypinus allapaticola). J. Mamm. 63:144-148.

Baskett, C. F. 1925. The Devonian Strata of the Alto Pass Quadrangle. Trans. Illinois State Acad. Sci. 18:360-368.

Birney, E. C. 1973. Systematics of three species of woodrats (Genus Neotoma) in Central North America. Univ. Kansas Publ. Mus. Nat. Hist. 58:1-173.

Brown, L. N. and R. L. Williams. 1971. The Key woodrat and cotton mouse on Lignum Vitae Key, Florida. Florida Nat. 44:95-96.

Burroughs, R. D. 1961. The natural history of the Lewis and Clark expedition. Michigan State Univ. Press, East Lansing, MI. 340pp.

Crim, J. 1961. The habitat of the woodrat in southern Illinois. M.A. Thesis. Southern Illinois Univ., Carbondale. 99pp.

Cudmore, W. 1983. The distribution and ecology of the eastern woodrat, (Neotoma floridana), in Indiana. PhD Dissertation. Indiana State Univ., Terre Haute. 148pp.

Erickson, R. 1980. Propagation studies of endangered wildlife at the Patuxent Center. International Zoo Yearbook Vol. 20.

Fitch, H. S. and D. G. Rainey. 1956. Ecological observations on the woodrat, Neotoma floridana. Univ. Kansas Publ. Mus. Nat. Hist. 8:499-533.

Hall, E. 1981. The mammals of North America. John Wiley & Sons, New York. 1181pp.

_____ and K. R. Kelson. 1959. The mammals of North America. Ronald Press, New York, NY. 1083pp.

Hamilton, W. J. 1953. Reproduction and young of the Florida woodrat, Neotoma f. floridana (Ord). J. Mammal. 34:180-189.

Howell, A. H. 1910. Notes on mammals of the Middle Mississippi Valley, with description of a new woodrat. Proc. Biol. Soc. Wash. 22:23-33.

Kinsey, K. P. 1976. Social behavior in confined populations of the Allegheny woodrat, *Neotoma floridana magister*. Anim. Behav. 24:181-187.

_____. 1977. Agonistic behavior and social organization in a reproductive population of Allegheny woodrats, *Neotoma floridana magister*. J. Mammal. 58(3):417-419.

Layne, J. N. 1955. The Illinois woodrat. The Living Museum 17(8):59-60.

Lowery, G. H., Jr. 1974. The mammals of Louisiana and its adjacent waters. Louisiana State Univ. Press, Baton Rouge. 565pp.

Mohlenbrock, R. H. 1959. A floristic study of a southern Illinois swampy area. Ohio J. Sci. 59(2):89-100.

Murphy, M. F. 1952. Ecology and helminths of the Osage wood rat, *Neotoma floridana osagensis*, including the description of *Longistriata neotoma* n. sp. (Trichostrongylidae). Am. Midl. Nat. 48:204-218.

Nawrot, J. R. 1974. The southern Illinois woodrat: an endangered species. M.A. Thesis. Southern Illinois Univ., Carbondale. 101pp.

_____ and W. D. Klimstra. 1976. Present and past distribution of the endangered southern Illinois woodrat (*Neotoma floridana illinoensis*). The Chicago Acad. Sci. Nat. Hist. Misc. No. 1976. 12pp.

_____ and W. D. Klimstra. 1981. Current status of the endangered Illinois woodrat. Job Completion Report, Illinois Endangered Species Program E-1-1. Springfield, IL 10pp.

Parmalee, P. W. 1959. Animal remains of the Modoc Rock Shelter Site, Randolph County, Illinois. Pages 61-65 *in* M. Fowler, ed. Rep. of Invest. No. 8, Summ. Rep. of Modoc Rock Shelter, 1952, 1953, 1955, 1956.

_____. 1967. A recent cave bone deposit in southwestern Illinois. Nat. Speleol. Soc. Bull. 29(4):119-147.

_____, R. A. Bieri, and R. K. Mohrman. 1961. Mammal remains from an Illinois cave. J. Mammal. 42(1):119.

Pearson, P. G. 1952. Observations concerning the life history and ecology of the woodrat, *Neotoma floridana floridana* (Ord). J. Mammal. 33:459-463.

Perez, J. C., W. C. Haws, and C. H. Hatch. 1978. Resistance of woodrats (*Neotoma micropus*) to *Crotalus atrox* venom. Toxicon 16:198-200.

Poole, E. L. 1940. A life history sketch of the Allegheny woodrat. J. Mammal. 21:249-270.

Rainey, D. G. 1956. Eastern woodrat, *Neotoma floridana*: Life history and ecology. Univ. Kansas Publ. Mus. Nat. Hist. 8(10):535-646.

Schlie, W. J. 1985. Reintroduction of the Allegheny woodrat (Neotoma floridana magister) to Neotoma Valley, Hocking County, Ohio. M. S. Thesis. Ohio State Univ., Columbia. 66pp.

Schwartz, A. and E. P. Odum. 1957. The woodrats of the eastern United States. J. Mammal. 38(2):197-206.

Schwegman, J. E. 1973. Comprehensive plan for the Illinois nature preserves system. II. The natural divisions of Illinois. Illinois Nature Preserves Commission. Rockford, IL. 32pp.

Soule', M. E. 1980. Thresholds for survival: maintaining fitness and evolutionary potential. Pages 151-169 in M. E. Soule' and B. A. Wilcox, eds. Conservation Biology: An Evolutionary - Ecological Perspective. Chapter 8. Publ. by Sinauer Assoc., Inc., Sunderland, MA.

Sweet, M. J. 1982. Eastern woodrat population monitoring. Unpubl. Rep. Illinois Endangered Species Protection Board, Springfield. 16pp.

_____. 1983. Illinois eastern woodrat population survey report. Unpubl. Rep. Illinois Endangered Species Protection Board, Springfield. 19pp.

_____. 1985. Illinois eastern woodrat population survey report. Unpubl. Rep. Illinois Endangered Species Protection Board, Springfield. 15pp.

U. S. Forest Service. 1970. Management plan: LaRue-Pine Hills Ecological Area, Shawnee National Forest, Illinois. U.S. Dept. of Ag. 33pp.

_____. 1986. LaRue Environmental Assessment Maintenance Project; water level restoration - LaRue Pine Hills Ecological Area. Unpubl. Proposal.

Voigt, J. W. and R. H. Mohlenbrock. 1964. Plant communities of southern Illinois. Southern Illinois Univ. Press, Carbondale, IL. 202pp.

Weller, J. M. and G. E. Ekblaw. 1940. Preliminary geological map of parts of the Alto Pass, Jonesboro, and Thebes Quadrangle. Illinois State Geol. Surv. Rep. Invest. No. 70. 26pp.

West, K. A. 1986. Illinois eastern woodrat population survey report. Unpubl. Rep. Illinois Endangered Species Protection Board, Springfield. 18pp.

Wetzel, R. M. 1947. Additional records of Illinois mammals. Trans. Illinois State Acad. Sci. 40:228-233.

Wiley, R. W. 1971. Activity periods and movements of the eastern woodrat. Southwestern Nat. 16:43-54.

Worth, C. B. 1950. Observations on the behavior and breeding of captive rice rats and woodrats. J. Mammal. 31:421-426.

APPENDIX A

Persons contacted regarding trapping of woodrats for release in Illinois:

ALABAMA: Dr. Joe Meyers, Non-game Program Coordinator
Department of Conservation and Natural Resources
64 N. Union Street
Montgomery, AL 36130

Telephone: (205)261-3469

ARKANSAS: Sam Barkley, Endangered Species Coordinator
Game and Fish Commission
#2 Natural resources Drive
Little Rock, AR 72205

Telephone: (501)223-6312

LOUISIANA: Nancy Craig, Endangered Species Coordinator/
Gary Lester, Zoologist
Louisiana Natural Heritage Section
P. O. Box 15570
Baton Rouge, LA 70895

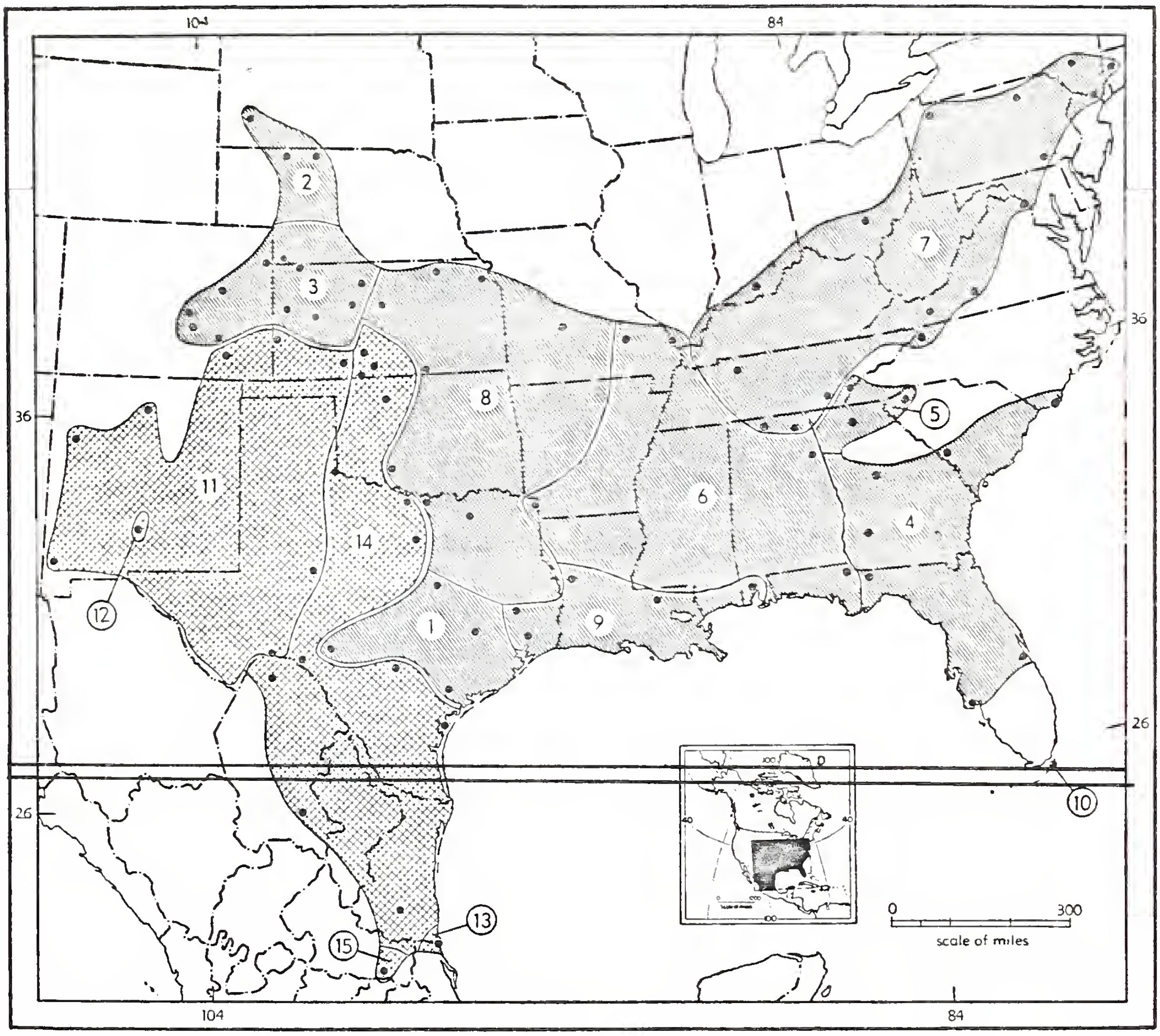
Telephone: (504)342-4602

MISSISSIPPI: Ken Gordon, Endangered Species Coordinator
Museum of Natural Science
Jackson, MS 39201

Telephone: (601)354-7303

MISSOURI: Jim Wilson, Endangered Species Coordinator
Missouri Natural Heritage Inventory
Missouri Department of Conservation
P. O. Box 180
Jefferson City, MO 65102

Telephone: (314)751-4115



1. *N. floridana attwateri*
2. *N. floridana baileyi*
3. *N. floridana campestris*
4. *N. floridana floridana*
5. *N. floridana haematoreia*
6. *N. floridana illinoensis*
7. *N. floridana magister*
8. *N. floridana osagensis*
9. *N. floridana rubida*
10. *N. floridana smalli*
11. *N. micropus canescens*
12. *N. micropus leucophaea*
13. *N. micropus littoralis*
14. *N. micropus micropus*
15. *N. micropus planiceps*

Figure 1. Distribution of subspecies of Neotoma floridana and Neotoma micropus. From Hall (1981).

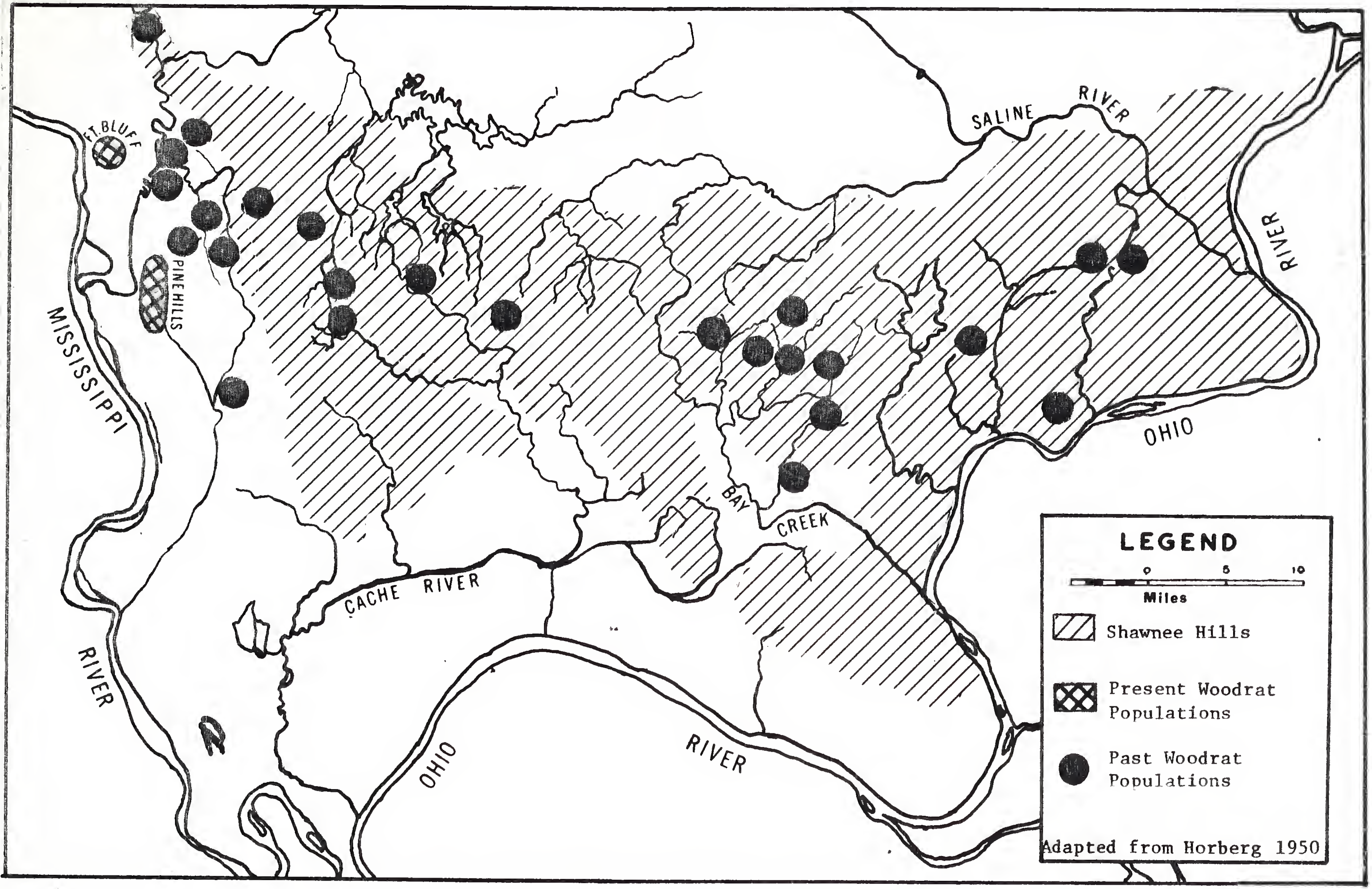


Figure 2. Distribution of past and present woodrat populations in southern Illinois. Modified from Nawrot and Klimstra (1976.

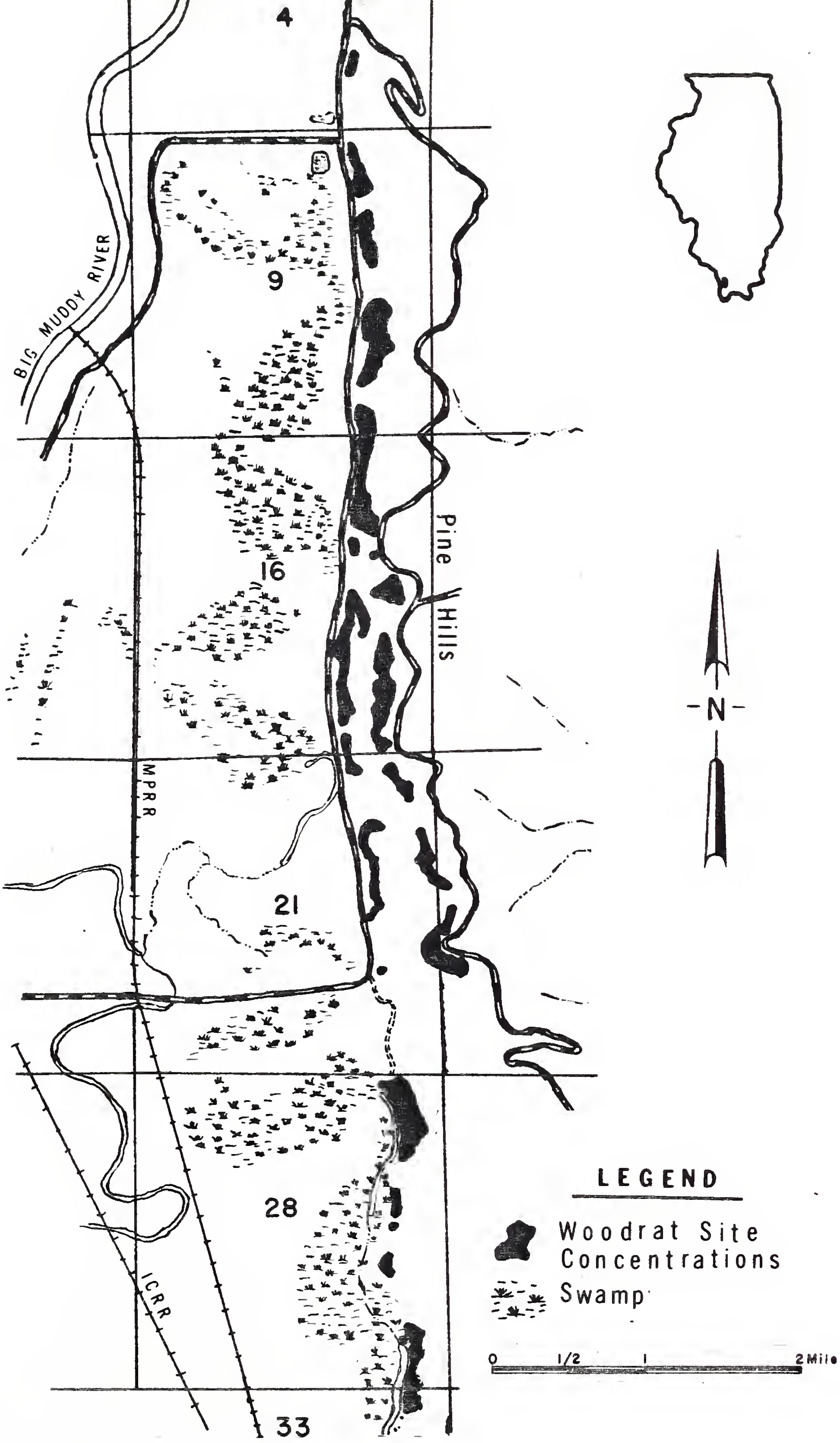


Figure 3. Distribution of woodrat site concentrations in the Pine Hills study area, Union County, Illinois. Modified from Nawrot (1974).

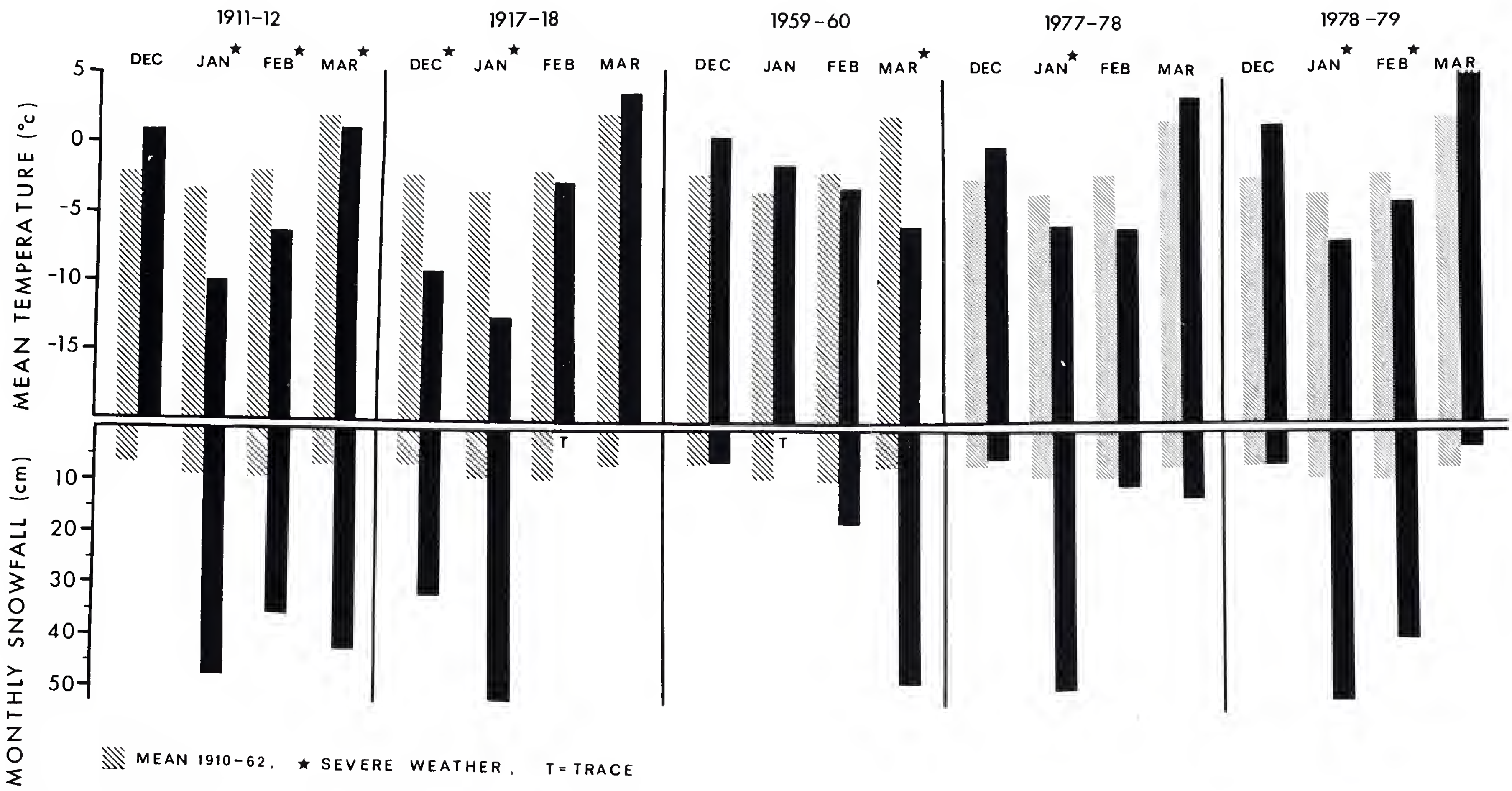


Figure 4. Climatological data for five periods of severe winter weather which may have had detrimental effects on southern Illinois woodrat (Neotoma floridana illinoensis) populations. From Changnon (1964), and Mitchell (1977, 1978, and 1979).